V.I.Kuvshinov[1], V.I.Kashkan[2], R.G.Shulyakovsky[3]

Institute of Physics, National Academy of Sciences of Belarus
F.Skorina av., 68, 220072 Minsk, BELARUS
[1]kashkan@dragon.bas-net.by
[2]kuvshino@dragon.bas-net.by
[3]shul@dragon.bas-net.by

Abstract

Possibility of experimental identification of QCD-instantons in high energy collisions is studied by means of correlations analysis in final states. Instanton-induced processes amplitudes are performed in the framework of QCD in Gauss approximation. Hadronization is taken into account by Monte-Carlo method. Obtained results can be used as additional criterions of QCD-instanton identification at HERA (DESY). Unlike previous results in this report we consider also nonzero quarks modes contribution into parton distributions of instanton processes.

1 Introduction

A possibility of strong growth of the cross-section of the *instanton* transitions in high energy collisions was mentioned first for electroweak theory [1] [1]. Shortly after this it was shown [2] that QCD-instantons can appear as a new channel of deep inelastic scattering (DIS) and be (in principle) observed at the present-day experiments unlike electroweak instantons. Specifically, QCD-instantons can be produced in quark-gluon subprocess at HERA (DESY) (Fig.1).

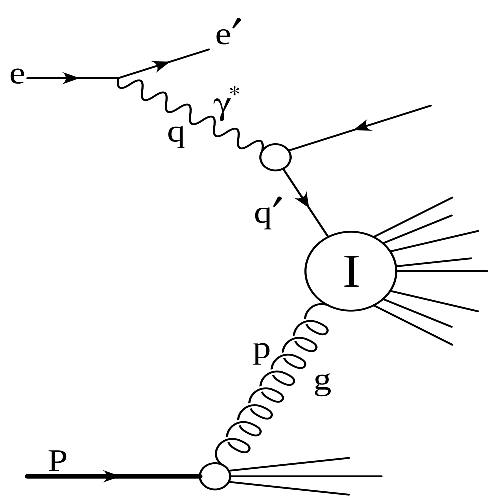

Fig.1. Instanton induced DIS at HERA.

[1]in electroweak theory these processes can become observable at energy about $O(10)$ TeV

A set of important features of the process (large number of secondary particles, specific behavior of cross-section and structure functions, large transversal energy flow and others) was already discussed by Schrempp, Ringwald and collaborators [3, 4]. It was shown that instanton fraction in DIS can reach 1%, but uncertainty inherent calculations in QCD does not allow to consider confidently that instanton channel in DIS is discovered.

2 Correlation criterions of QCD-instantons in DIS

We consider that analysis of correlations in DIS may be helpful for the solving of the problem of experimental identification of QCD-instanton. Preliminary results (calculation of 2-particle correlation function [5], factorial and H_q-moments [6]) showed that instanton-induced processes are characterized by specific form of correlation characteristics at parton level. Footprints of these features persist after hadronization. In particular normalized factorial moments for instanton processes grow very slowly (Fig.2), H_q-moments are characterized by first minima at $q = 2$ unlike ordinary DIS (Fig.3) [7]. Hadronization was taken into account by means of Monte-Carlo package QCDINS [4] (the programm which generates QCD-instanton-induced events).

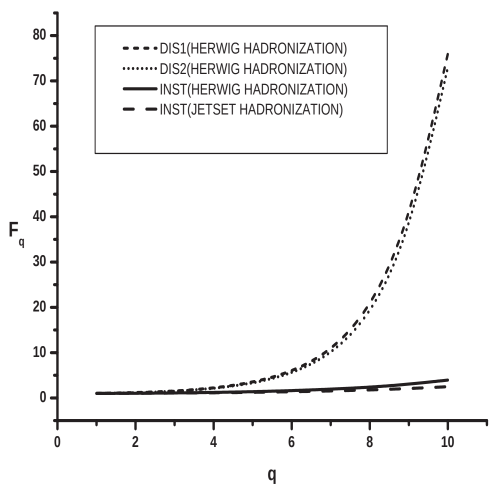

Fig.2. F_q for one-jet (DIS1), 2-jet (DIS2) and instanton induced DIS (INST).

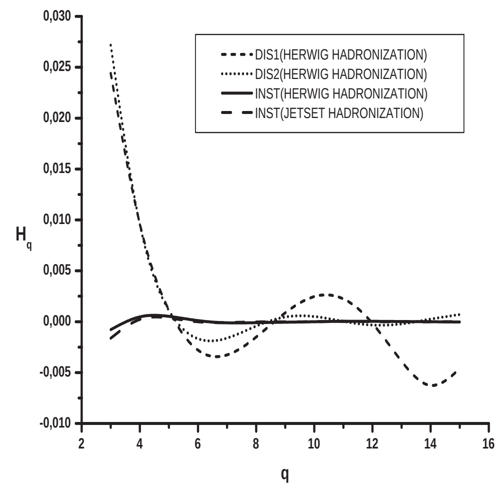

Fig.3. H_q for one-jet (DIS1), 2-jet (DIS2) and instanton induced DIS (INST).

Thus correlation properties of instanton-induced DIS can be considered as new criterions of the QCD-instanton identification in addition to criterions of Schrempp, Ringwald et al. [3, 4].

3 Contribution of nonzero quark modes

Usually it is supposed that only minimal number of quarks is produced after "decay" of instanton (number of final gluons is supposed to be arbitrary):

$$q + g \to (2n_f - 1)q + n_g g. \qquad (1)$$

This supposition was used by authors of the package QCDINS [3, 4] as well as in Ref. [7].

tribution of these processes is determined by nonzero fermion propagator [8]

$$S^{nz}(x,y) = \frac{1}{\sqrt{1+\rho^2/x^2}}\frac{1}{\sqrt{1+\rho^2/y^2}}\Bigg[\frac{(x-y)_\mu\sigma_\mu}{2\pi^2(x-y)^4}\left(1+\rho^2\frac{x_\nu\sigma_\nu y_\kappa\bar\sigma_\kappa}{x^2y^2}\right)-$$
$$-\frac{\rho^2}{4\pi^2(x-y)^2x^2y^2}\left(\bar\sigma_\mu\frac{x_\nu\sigma_\nu\bar\sigma_\mu(x-y)_\lambda\sigma_\lambda y_\omega\bar\sigma_\omega}{\rho^2+x^2}+\sigma_\mu\frac{x_\nu\sigma_\nu(x-y)_\lambda\bar\sigma_\lambda\sigma_\mu y_\omega\bar\sigma_\omega}{\rho^2+y^2}\right)\Bigg], \qquad (2)$$

where ρ is instanton size, $\sigma_\mu = (-i\sigma_a, I)$, $\bar\sigma_\mu = (i\sigma_a, I)$.

After calculation[2] we obtain Poisson distribution on number of quark pairs (for every light quarks), which are produced in the instanton processes:

$$P_n = [e^{\xi^2}-1]^{-1}\frac{\xi^{2n}}{n!}, \quad \xi \approx \frac{1-x'}{x'}, \qquad (3)$$

where Bjorken variable of instanton subprocess $x' > 0.5$. Average number of quark pairs for small ξ reads

$$< n > \approx 3(1+\xi^2). \qquad (4)$$

Contribution of non-zero modes can lead to another behavior of characteristics of instanton processes and be important for the experimental search of QCD-instantons. Monte-Carlo simulation is in progress.

References

[1] A.Ringwald, *Nucl.Phys.* **B330** 1 (1990).

[2] I.Balitsky and V.Braun, *Phys.Lett.* **B314** 237 (1993).

[3] S.Moch, A.Ringwald, F.Schrempp, *Nucl.Phys.* **B507** 134 (1997),
A.Ringwald, F.Schrempp, *Phys.Lett.* **B438** 217 (1998),
A.Ringwald, F.Schrempp, *J.Phys.* **G25** 1297 (1999),
A.Ringwald, F.Schrempp, *Phys.Lett.* **B495** 249 (1999).

[4] T.Carli, J.Gerigk, A.Ringwald, F.Schrempp. *Monte Carlo Generators for HERA Physics. Proceed. of the Workshop 1998-1999. Ed. by A.T. Doyle et al.* (1999) 329.

[5] V.Kuvshinov and R.Shulyakovsky, *Acta Phys.Pol.* **B28** (1997) 1629, hep-ph/9902403.

[6] V.Kuvshinov and R.Shulyakovsky, *Acta Phys.Pol.* **B30** (1999) 69, hep-ph/9902379.

[7] V.I.Kuvshinov, V.I.Kashkan, R.G.Shulyakovsky, *Proceed. of the IXth Annual Seminar "Nonlinear phenomena in complex systems" (May 16-19, 2000, Minsk, Belarus)* (2000) 292;
V.I.Kuvshinov, V.I.Kashkan, R.G.Shulyakovsky, submitted to *Yad.Fiz.* 2001 (in Russian).

[8] T.Schaefer, E.Shuryak, *Rev.Mod.Phys.* **70** 323 (1998).

[9] R.Shulyakovsky, *Proceed. of the Xth. International Seminar "Nonlinear phenomena in complex systems" (May 15-18, 2001, Minsk, Belarus)*, to be published, hep-ph/0105314.

[2] for detailed explanation of calculation of the distribution of multiplicity on quarks produced after instanton "decay" see [9]